Emotional Memory Under Divided Attention

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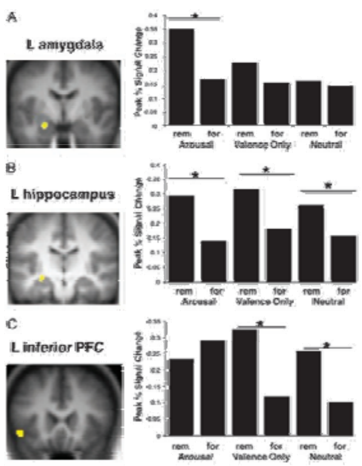
1. Background

Emotional enhancement of memory (EEM) has often been referred to as the valence enhancement effect, suggesting that it is *solely* the valence of the stimuli being studied (positive, neutral, negative) that determines the ultimate differences in memory for those stimuli. Researchers have used both fMRI (Kensinger & Corkin, 2004) and traditional memory (Clark-Foos & Marsh, 2008) approaches to examine the automaticity of EEM and have generally concluded that it is dependent upon the physiological arousal value (high or low) for the stimuli (see figure for examples). Specifically, negative information will activate greater amygdala efferent pathways and result in an automatic encoding of the stimulus *IFF* the stimulus is also highly arousing. For negative stimuli with low arousal values the amygdala is less active and the EEM is due to greater PFC activation, representing a controlled process that are susceptible to available resources during encoding.

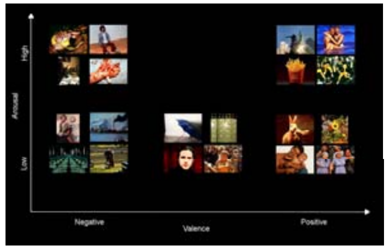


From Kensinger & Corkin (2004)

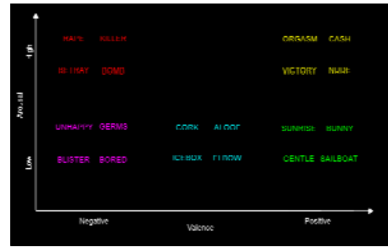
Recent (2010) fMRI data suggest that the arousal effect on emotional memory is not merely a main effect but rather an interaction. That is, arousal does not serve to merely increase the automaticty of encoding (and amygdala activation) for any valenced stimulus. In fact, the direction of the effect for positively valenced stimuli is reversed such that positive stimuli with higher arousal values actually activate the PFC (and not the amygdala; Steinmetz, Addis, & Kensinger, 2010). The reverse is true for positive low arousing stimuli: they activate the amygdala more than the PFC. It remains to be seen how these varying routes might lead to differences in the automaticity of memory encoding for these stimulus types.

Our research represents an attempt to build upon the recent fMRI work with positive stimuli to determine if the automatic EEM that comes with negative arousing stimuli will also be present for the other class of stimuli known to activate the amygdala, namely positive nonarousing. We also aim to see If reducing processing resources (through divided attention) will eliminate the EEM for stimulus types known to rely on PFC activation, namely positive arousing and negative nonarousing.

2. Materials



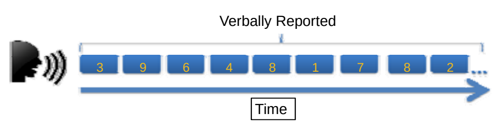
- 350 pictures from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008)
- Pictures were chosen from five distinct categories, pictured above: Negative Arousing, Negative Nonarousing, Neutral, Positive Arousing, and Positive Nonarousing
- These stimuli are identical to those used in previous studies (c.f., Steinmetz et al., 2010)



- 240 words from the Affective Norms for English Words (ANEW; Bradley & Lang, 1999)
- Words were chosen from five distinct categories, pictured above: Negative Arousing, Negative Nonarousing, Neutral, Positive Arousing, and Positive Nonarousing
- These stimuli are identical to those used in previous studies (c.f., Clark-Foos & Marsh, 2008)

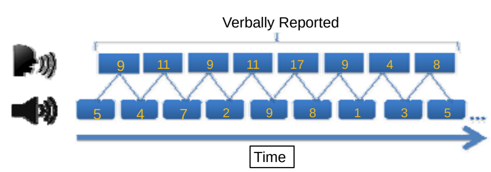
3. Divided Attention Tasks

Random Number Generation (RNG)



Note: Participants were required to verbally speak an integer 1-10 at a two second interval (paced by auditory beep tape) throughout the entire study phase

Paced Auditory Self Addition Task (PASAT)



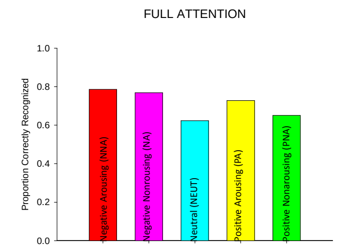
Note: Participants were required to listen to an audio track that played single digits at a two second pace and adding the two most recently heard numbers, saying the sum out loud for the experimenter to record.

4. Experimental Design

210 participants from the University of Michigan Dearborn were asked to study either 120 words or 175 pictures, divided equally between 5 distinct stimulus types representing 3 valence categories and 2 levels of arousal (neutral items are only low arousal). The result was two between subjects conditions manipulating stimulus format (word vs. picture). In order to investigate the contribution of controlled and automatic processes to the learning of these stimuli, participants in two thirds of our conditions were asked to complete some form of divided attention task *at the same time* as they were studying.

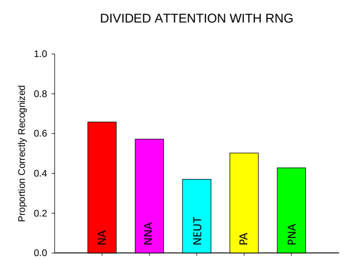
5. Results

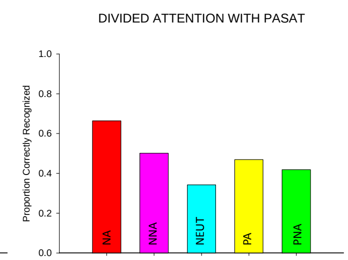
To begin we conducted a 2 (arousal) x 3 (valence) x 3 (attention) x 2 (stimulus format) omnibus ANOVA on the proportion of correctly recognized stimuli (hit rate). Stimulus format did not produce any significant interactions so results of a reduced ANOVA, pooling over that factor, are reported below:



- **Main Effects**:
  - **Valence** = F (1, 209) = 167.6, $p < .001$, $\eta_p^2 = .45$
  - **Arousal** = F (1, 209) = 107.7, $p < .001$, $\eta_p^2 = .34$
  - **Attention** = F (2, 209) = 56.8, $p < .001$, $\eta_p^2 = .35$
- **Two-Way Interaction**:
  - **Valence X Attention** = F (2, 209) = 8.16, $p < .001$, $\eta_p^2 = .07$

**** Three-Way Interaction ****
Valence X Arousal X Attention = F (2, 209) = 3.89, $p < .02$, $\eta_p^2 = .04$





6. Discussion

To briefly summarize the impact of these data, they confirm that EEM occurs for both Positive and Negative stimuli. They also qualify the Steinmetz et al. (2010) finding that positive nonarousing stimuli activate similar pathways as negative arousing (i.e., amygdala efferents). Our data suggest that any automaticity afforded to encoding of positive stimuli acts in the same way as it does for negative stimuli (regardless of the pattern of neural activation). That is, we show that higher arousal always leads to better memory, even when processing resources are heavily taxed.

7. Acknowledgments & Reprint Requests

We would like to thank the University of Michigan – Dearborn and The Human Learning & Creativity (HuLC) Laboratory for assistance in collecting the data. For reprint requests, please email umdmemory@gmail.com.